Ontario Geological Survey

Northern Ontario

Engineering Geology Terrain Study 1

ONTARIO ENGINEERING GEOLOGY TERRAIN STUDY USERS' MANUAL

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MINISTRY OF NORTHERN DEVELOPME 1
AND MINES

by

Not for resale

John F. Gartner, J.D. Mollard, and M.A. Roed

1981

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ABSTRACT

This Manual is a companion volume to two new series of publicaions entitled "Northern Ontario Engineering Geology Terrain Studies" and "Southern Ontario Engineering Geology Terrain Studies", published by the Ontario Geological Survey. The Studies and the Manual are the results of a program of terrain evaluation carried out during the period 1977 to 1979. Under this program a large part of the terrain conditions of northern Ontario between Latitudes 45°N and 51°N were mapped. Upon completion of the program, 110 Studies each containing a brief report and one or more maps on a scale of 1:100 000 will have been published.

The Users' Manual describes the scope of the mapping program and the techniques used to evaluate and portray the engineering terrain conditions over all the areas, whereas the individual Studies and the accompanying maps present the results of investigation of a particular area. The Manual describes the elements of the legend used to portray the four basic engineering terrain characteristics: material, landform, topography, and drainage. The engineering significance of the different terrain units mapped is explained. The Manual provides guidelines to the users for interpreting and deriving specific types of information from the maps, and it includes examples of derived information and a glossary to explain the technical terms used.

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

If the reader wishes to convert imperial units to SI (metric) units or SI units to imperial units the following multipliers should be used:

CONVERSION FROM SI TO IMPERIAL			CONVERSION FROM IMPERIAL TO SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
			AREA		
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
			VOLUME		
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
			CAPACITY		
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
			MASS		
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
			CONCENTRATION		
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy)/ton (short)	20.0	pennyweights/ton (short)
1 pennyweight/ton (short)	0.05	ounce (troy)/ton (short)

NOTE–Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries published by The Mining Association of Canada in co-operation with the Coal Association of Canada.

Ontario Engineering Geology Terrain Study Users' Manual

by

John F. Gartner[1], J.D. Mollard[2], and M.A. Roed[3]

INTRODUCTION

PURPOSE AND SCOPE OF THE MANUAL

The geologic conditions of the land can give it resource capabilities but can also pose constraints that have substantial economic and cultural consequences. These geologic conditions have recently been outlined for a large part of Ontario during a program referred to as the Ontario Engineering Geology Terrain Study. The terrain mapping was conducted on a reconnaissance basis, and resulted in the publication of a series of folios that contain one or more maps and a report.

All of the information was prepared in a manner that allows assessment of the geologic conditions for regional planning purposes. This manual provides a guide and reference framework to assist users of the terrain information contained in the individual studies.

The manual first describes the mapping program and the techniques employed to gather the terrain information and present it on Data Base Maps at a scale of 1:100 000. Philosophies used in derived the mapping legend are then outlined. This is followed by a generalized description of the engineering characteristics of the various terrain units shown on the maps. The manual concludes with a broad-ranging discussion of the principles and guidelines for deriving user information, together with some examples of derived data.

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[1]Consulting Engineering Geologist, Gartner Lee Associates Limited, Markham, Ontario.

[2]Consulting Engineering Geologist, J.D. Mollard and Associates Limited, Regina, Saskatchewan.

[3]Geological Consultant, Geo-analysis Limited, Ottawa, Ontario.

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The manual does not attempt to define all of the engineering properties associated with landforms, materials, topography, and drainage features of the terrain. Rather, it explains how these components are interrelated, and how a knowledge of such relationships can be used to infer an engineering significance for the terrain.

ACKNOWLEDGMENTS

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CHAPTER TWO
The Mapping Program

WHAT IS AN ENGINEERING GEOLOGY TERRAIN STUDY?

An engineering geology terrain study is an evaluation of near-surface geological conditions for the purpose of determining the engineering significance of the terrain. In this context, terrain refers to the physical aspect and characteristics of an area or landscape under observation. The main investigative techniques used to gather the information for such a study are airphoto interpretation combined with literature searches and limited field work.

In 1977, the Ontario Geological Survey of the Ministry of Natural Resources began a comprehensive study of the terrain conditions in Ontario. The purposes of this program are to provide:

1. engineering geology terrain data on 1:100 000 scale maps,
2. a written description of the terrain conditions in each map-area,
3. examples of the types of maps that can be derived from the basic engineering terrain data,
4. an information base that can be utilized by planners, engineers, exploration managers, administrators, and politicians to aid in formulating development strategies and plans for all parts of Ontario, and
5. data bases that show the resource potential of the Quaternary deposits.

The study has resulted in the production of a series of Data Base maps. Each map is accompanied by a report that describes the terrain conditions and the engineering significance of these conditions. For some map-areas, a second map has been published which presents the terrain data in a "derived" form related to a specific engineering use. Thus, a folio has been produced for each map area (Table 1). For example, the Cartier folio contains a written report, a Data Base Map, and a derived map showing the General Construction Capability of the terrain.

The information contained in the series is of a reconnaissance nature, designed to provide an overview of the terrain conditions. At this level of detail, the folios are meant to provide a framework for regional planning studies and a data base on which to undertake more site-specific studies.

HOW MUCH OF THE PROVINCE HAS BEEN MAPPED?

A total of 370 000 km^2 of northern Ontario was mapped between 1977 and 1980. This amounts to one-third of the province or almost 4 percent of Canada. The program, referred to as the Northern Ontario Engineering Geology Terrain Study (NOEGTS), was undertaken in three phases:

Phase I (1977 to 1978) - 150 000 km^2 mapped,
Phase II (1978 to 1979) - 147 000 km^2 mapped, and
Phase III (1979 to 1980) - 73 000 km^2 mapped.

The area covered during each phase is outlined in Figure 1.

Approximately 30 000 km^2 of southern Ontario was also mapped during 1979 and 1980 (Figure 1). This program, referred to as the Southern Ontario Engineering Geology Terrain Study (SOEGTS), encompasses most of the Algonquin Region. There are plans to extend the mapping to other parts of southeastern Ontario.

A major benefit of this program is the publication of more than 100 separate maps with identical scales and legend formats. When placed side by side, these maps cover almost all of Ontario between Latitudes 45°N and 51°N. Table 1 is a complete listing of the reports and maps to be published under the Northern Ontario Engineering Geology Terrain Study. Table 2 is a listing of reports and maps covering areas under the Southern Ontario Engineering Geology Terrain Study.

METHODOLOGY

The investigative techniques include the review of relevant literature to provide a source of published information, airphoto interpretation to identify and classify terrain types, and field surveys to verify ground conditions at specific locations.

LITERATURE REVEIW

A considerable amount of technical information dealing with the terrain was available from many literature sources. One of the first tasks, therefore, was to research this literature and compile a body of pertinent geological and engineering data.

To achieve this, existing government reports and maps were collected and studied. Information was obtained, for example, from the Ontario Ministry of Natural Resources, the Ontario Ministry of Transportation and Communications, Ontario Hydro, the Geological Survey of Canada, and a number of municipalities, private firms, and other government agencies. Each terrain report contains a list of the references used in the investigation of that particular map-area.

The 1:50 000 National Topographic System (NTS) maps provide invaluable topographic data and should be used in conjunction with the Data Base Map when interpreting the terrain results.

AIRPHOTO INTERPRETATION

The principal technique for obtaining terrain information was stereoscopic airphoto interpretation. The terrain units were delineated on contact prints of these airphotos and decisions were made regarding the terrain type and its distribution. Between 1977 and 1980, this interpretation was carried out on approximately 12 000 vertical airphotos which varied in scale from 1:38 000 to 1:70 000.

The interpretations were transferred manually from the contact prints onto photo mosaics at a scale of 1:100 000. From these mosaics, the information was traced to the finished base map at the same scale.

GROUND SURVEYS

Field surveys were undertaken to verify the terrain conditions obtained from the airphoto interpretation; these were carried out by the senior interpreters. Because of the reconnaissance nature of the study and the inherent time constraints, the field checking took the form of a "windshield survey". Prominent natural and man-made cuts were examined, and, in some cases, soil materials were sampled. Geological observations were recorded on a continuous basis along most of the accessible roads and highways within the map-areas. A helicopter reconnaissance survey was conducted in the inaccessible area north of Lake Nipigon. A few shallow hand auger holes were drilled by some of the investigators, and a number of photographs were taken.

The information from the field survey and literature research was combined with the airphoto interpretation results to produce the Data Base Map and written report for each map-area.

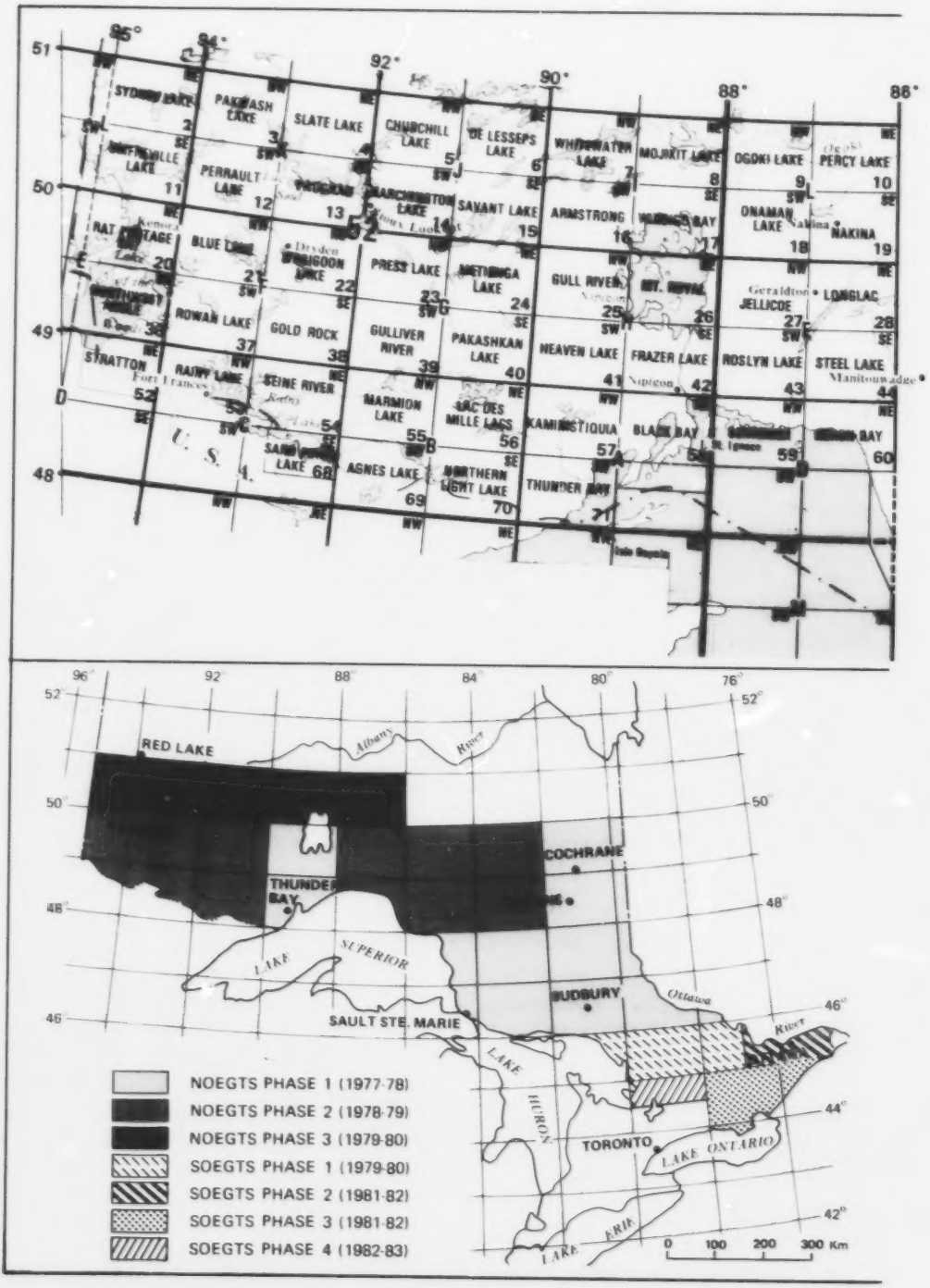
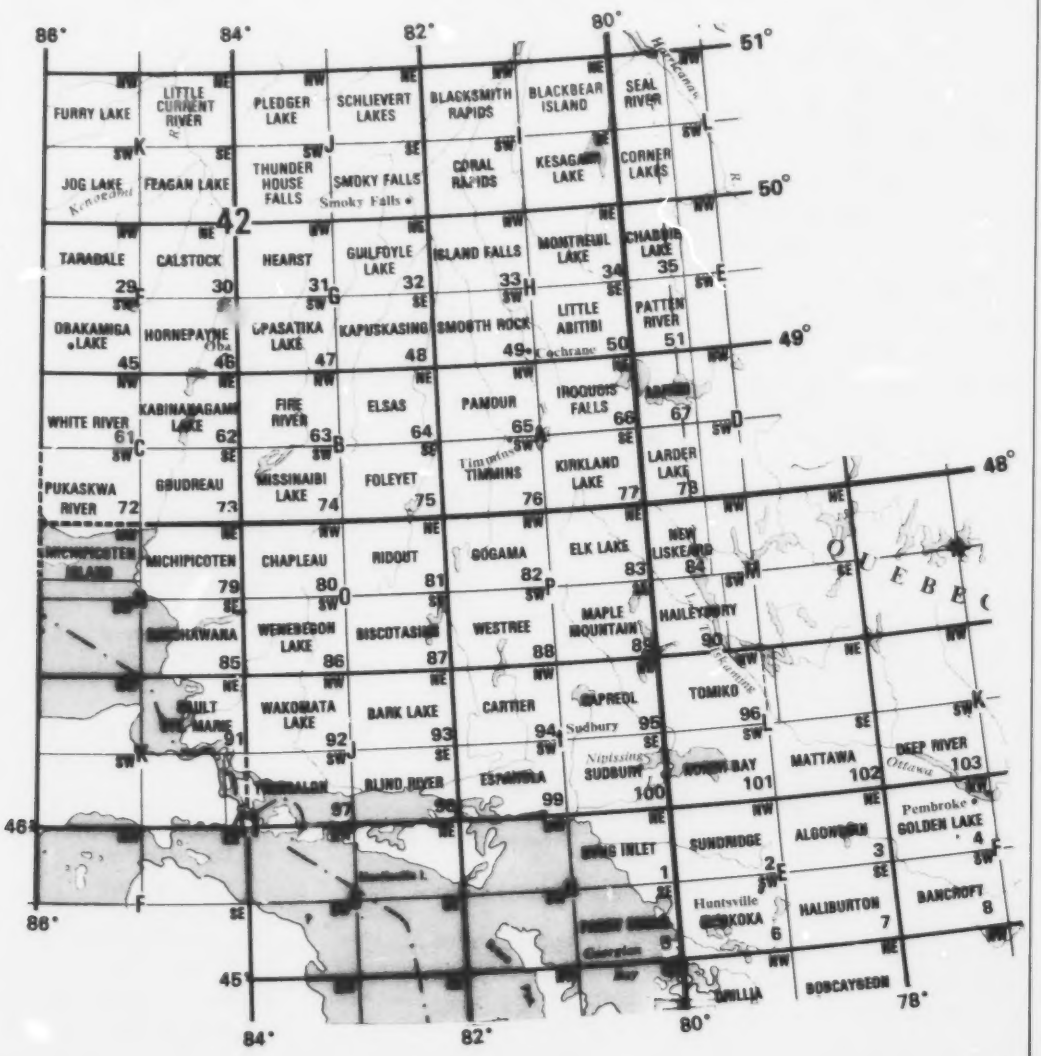


Figure 1 – Locations of areas mapped under the Northern and Southern Ontario Engineering Geology Terrain Study programs.



LEGEND

ELSAS 64 — Area name and study number

ALL MAPS ARE AT SCALE OF 1:100 000

TABLE 1 | NORTHERN ONTARIO ENGINEERING GEOLOGY TERRAIN STUDIES

Study Number	Area	District	NTS Map Reference	Data Base Map Number	Derived Map Number	Derived Map Name
1	Ontario Engineering Geology Terrain Study Users' Manual					
2	Sydney Lake	Kenora	52 L/NE	5105		
3	Pakwash Lake	Kenora	52 K/NW	5107	5111	General Construction Capability Map
4	Slate Lake	Kenora	52 K/NE	5108		
5	Churchill Lake	Kenora	52 J/NW	5112		
6	de Lesseps Lake	Kenora and Thunder Bay	52 J/NE	5113		
7	Whitewater Lake	Thunder Bay	52 I/NW	5117		
8	Mojikit Lake	Thunder Bay	52 I/NE	5118		
9	Ogoki Lake	Thunder Bay	42 L/NW	5122		
10	Percy Lake	Cochrane and Thunder Bay	42 L/NE	5123		
11	Umfreville Lake	Kenora	52 L/SE	5106		
12	Perrault Lake	Kenora	52 K/SW	5109		
13	Vaughan	Kenora	52 K/SE	5110		
14	Marchington Lake	Kenora	52 J/SW	5114	5116	Sand and Gravel Resources Map
15	Savant Lake	Kenora and Thunder Bay	52 J/SE	5115		
16	Armstrong	Thunder Bay	52 I/SW	5119		
17	Windigo Bay	Thunder Bay	52 I/SE	5120		
18	Onaman Lake	Thunder Bay	42 L/SW	5124		
19	Nakina	Cochrane and Thunder Bay	42 L/SE	5125	5126	Mineral Exploration Capability Map
20	Rat Portage Bay	Kenora	52 E/NE	5055	5057	Sand and Gravel Resources Map
21	Blue Lake	Kenora	52 F/NW	5058		
22	Wabigoon Lake	Kenora	52 F/NE	5059		
23	Press Lake	Kenora	52 G/NW	5062	5066	Sand and Gravel Resources Map
24	Metionga Lake	Kenora and Thunder Bay	52 G/NE	5063		
25	Gull River	Thunder Bay	52 H/NW	5049	5053	Groundwater Development Capability Map
					5054	Solid Waste Disposal Capability Map
26	Mt. Royal	Thunder Bay	52 H/NE	5050		
27	Jellicoe	Thunder Bay	42 E/NW	5077		
28	Longlac	Cochrane and Thunder Bay	42 E/NE	5078	5081	Sand and Gravel Potential Map
29	Taradale	Cochrane and Algoma and Thunder Bay	42 F/NW	5082		

TABLE 1 | Continued

Study Number	Area	District	NTS Map Reference	Data Base Map Number	Derived Map Number	Derived Map Name
30	Calstock	Cochrane and Algoma	42 F/NE	5083	5086	General Construction Capability Map
31	Hearst	Cochrane	42 G/NW	5087		
32	Guilfoyle Lake	Cochrane	42 G/NE	5088		
33	Island Falls	Cochrane	42 H/NW	5033		
34	Montreuil Lake	Cochrane	42 H/NE	5034		
35	Chabbie Lake	Cochrane	32 E/NW	5035		
36	Northwest Angle	Kenora and Rainy River	52 E/SE	5056		
37	Rowan Lake	Kenora and Rainy River	52 F/SW	5060		
38	Gold Rock	Kenora and Rainy River	52 F/SE	5061		
39	Gulliver River	Kenora and Rainy River	52 G/SW	5064	5067	General Construction Capability Map
40	Pakashkan Lake	Kenora, Thunder Bay and Rainy River	52 G/SE	5065		
41	Heaven Lake	Thunder Bay	52 H/SW	5051		
42	Frazer Lake	Thunder Bay	52 H/SE	5052		
43	Roslyn Lake	Thunder Bay	42 E/SW	5079		
44	Steel Lake	Thunder Bay	42 E/SE	5080		
45	Obakamiga Lake	Thunder Bay and Algoma	42 F/SW	5084		
46	Hornepayne	Algoma and Cochrane	42 F/SE	5085		
47	Opasatika Lake	Algoma and Cochrane	42 G/SW	5089		
48	Kapuskasing	Algoma and Cochrane	42 G/SE	5090	5091	Terrain Conditions for Pipeline Construction
49	Smooth Rock	Cochrane	42 H/SW	5036		
50	Little Abitibi	Cochrane	42 H/SE	5037	5039	Exploration Capability Map
51	Patten River	Cochrane	32 E/SW	5038		
52	Stratton	Rainy River	52 D/NE	5068		
53	Rainy Lake	Rainy River	52 C/NW	5069		
54	Seine River	Rainy River	52 C/NE	5070	5072	Sand and Gravel Resources Map
55	Marmion Lake	Rainy River	52 B/NW	5073	5104	General Construction Capability Map
56	Lac des Mille Lacs	Thunder Bay and Rainy River	52 B/NE	5074		
57	Kaministikwia	Thunder Bay	52 A/NW	5045		
58	Black Bay	Thunder Bay	52 A/NE	5046		

TABLE 1 | Continued

Study Number	Area	District	NTS Map Reference	Data Base Map Number	Derived Map Number	Derived Map Name
59	Schreiber	Thunder Bay	42 D/NW	5092		
60	Heron Bay	Thunder Bay	42 D/NE	5093		
61	White River	Algoma and Thunder Bay	42 C/NW	5094	5098	Septic Systems Capability Map
62	Kabinakagami Lake	Algoma	42 C/NE	5095		
63	Fire River	Algoma	42 B/NW	5099	5103	Terrain Conditions for General Construction
64	Elsas	Algoma and Cochrane	42 B/NE	5100		
65	Pamour	Cochrane	42 A/NW	5026		
66	Iroquois Falls	Cochrane	42 A/NE	5027		
67	Abitibi	Cochrane	32 D/NW	5028		
68	Sand Point Lake	Rainy River	52 C/SE	5071		
69	Agnes Lake	Rainy River	52 B/SW	5075		
70	Northern Light Lake	Rainy River and Thunder Bay	52 B/SE	5076		
71	Thunder Bay	Thunder Bay	52 A/SW	5047	5048	Light Construction Capability Map
72	Pukaskwa River	Algoma and Thunder Bay	42 C/SW	5096		
73	Goudreau	Algoma and Sudbury	42 C/SE	5097		
74	Missinaibi Lake	Algoma and Sudbury	42 B/SW	5101		
75	Foleyet	Sudbury, Algoma and Cochrane	42 B/SE	5102		
76	Timmins	Sudbury, Timiskaming and Cochrane	42 A/SW	5029		
77	Kirkland Lake	Timiskaming and Cochrane	42 A/SE	5030	5032	Sand and Gravel Resources Map
78	Larder Lake	Timiskaming and Cochrane	32 D/SW	5031		
79	Michipicoten	Algoma and Sudbury	41 N/NE	5010		
80	Chapleau	Algoma and Sudbury	41 O/NW	5014	5018	Engineering Capability Map
81	Ridout	Sudbury	41 O/NE	5015		
82	Gogama	Timiskaming and Sudbury	41 P/NW	5019		
83	Elk Lake	Timiskaming	41 P/NE	5020		
84	New Liskeard	Timiskaming	31 M/NW	5021	5025	Sand and Gravel Resources Map

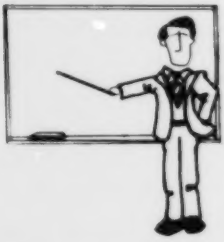
TABLE 1 | Continued

Study Number	Area	District	NTS Map Reference	Data Base Map Number	Derived Map Number	Derived Map Name
85	Batchawana	Algoma	41 N/SE	5011		
86	Wenebegon Lake	Algoma and Sudbury	41 O/SW	5016		
87	Biscotasing	Algoma and Sudbury	41 O/SE	5017		
88	Westree	Sudbury and Timiskaming	41 P/SW	5022		
89	Maple Mountain	Sudbury, Timiskaming and Nipissing	41 P/SE	5023		
90	Haileybury	Timiskaming and Nipissing	31 M/SW	5024		
91	Sault Ste. Marie	Algoma	41 K/NE	5012	5013	General Construction Capability Map
92	Wakomata Lake	Algoma	41 J/NW	5005		
93	Bark Lake	Algoma and Sudbury	41 J/NE	5006		
94	Cartier	Algoma and Sudbury	41 I/NW	5000	5004	General Construction Capability Map
95	Capreol	Sudbury and Nipissing	41 I/NE	5001		
96	Tomiko	Nipissing	31 L/NW	5040		
97	Thessalon	Algoma	41 J/SW	5007	5009	Sand and Gravel Resources Map
98	Blind River	Algoma, Manitoulin and Sudbury	41 J/SE	5008		
99	Espanola	Manitoulin and Sudbury	41 I/SW	5002		
100	Sudbury	Sudbury, Parry Sound and Nipissing	41 I/SE	5003		
101	North Bay	Nipissing and Parry Sound	31 L/SW	5041	5044	Septic Systems Capability Map
102	Mattawa	Nipissing and County of Renfrew	31 L/SE	5042		
103	Deep River	Nipissing and County of Renfrew	31 K/SW	5043		

TABLE 2 | SOUTHERN ONTARIO ENGINEERING GEOLOGY TERRAIN STUDIES *

Study Number	Area	District or County	NTS Map Reference	Data Base Map Number	Derived Map Number	Derived Map Name
1	Byng Inlet	Parry Sound	41 H/NE	5500		
2	Sundridge	Parry Sound and Nipissing	31 E/NW	5502		
3	Algonquin	Nipissing, Muskoka and Haliburton	31 E/NE	5503		
4	Golden Lake	Renfrew and Nipissing	31 F/NW	5507		
5	Parry Sound	Parry Sound and Muskoka	41 H/SE	5501		
6	Muskoka	Parry Sound and Muskoka	31 E/SW	5504		
7	Haliburton	Muskoka, Haliburton, Nipissing and Hastings	31 E/SE	5505	5506	Sand and Gravel Resources Map
8	Bancroft	Hastings, Lennox and Addington, Renfrew, Frontenac and Nipissing	31 F/SW	5508	5509	General Construction Capability Map

*Additional studies are planned (see Figure 1) but study numbers and map-area names were not available at the time of publication.



CHAPTER THREE
The Legend

The derivation of a common legend was an important part of the program. It was decided that the legend must fulfill four major objectives:

1. to accurately reflect the engineering characteristics of the terrain,
2. to be mappable on aerial photographs,
3. to be applicable to all of Ontario, and
4. to allow the derivation of user maps.

The major question that confronted the interpreters in deriving a legend was, which components reflect the engineering characteristics of the terrain. After much discussion and study, it was decided that these four components would be most useful: landform, material, topography, and drainage. The rationale behind these choices is outlined below.

COMPONENTS OF THE LEGEND

LANDFORM

Many engineering characteristics of a landform are related to the geological processes of erosion, transportation, and deposition of the materials, which contribute to the formation of the landform. The effects of these processes can be inferred if one can identify the origin of the terrain unit. Thus the landform, which is related directly to its geologic origin, is the prime mapping unit.

MATERIAL

Knowledge of the origin of a landform, together with the type and texture of the material allows the interpreter to infer types of soil and rock materials and thus the geotechnical properties of the various terrain units. For this reason, material is a main parameter in the legend.

TOPOGRAPHY

The relative relief and topographic variety of a landform are important modifiers that can have an engineering significance. Thus a combined designation of relief and topographic variety was included.

DRAINAGE

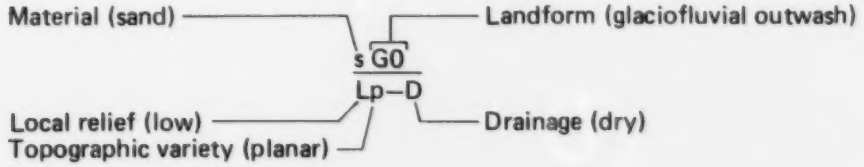
Both surface and internal drainage conditions have important engineering significance. These can be inferred from the airphotos and have been included as the last component in the legend.

FORMAT OF THE LEGEND

The four components to be included in the legend (landform, material, topography, and drainage) were arranged in a format suitable for map presentation. Each component is fixed as to its position in the format. This arrangement, called the *terrain unit letter code*, is as follows:

MATERIAL	LANDFORM
TOPOGRAPHY	DRAINAGE

Each component within the *letter code* is described by upper and lower case *letter symbols*. The following example illustrates this:



The relevant letter symbols for each of the components and their principal variations are described in the next section, and shown in Table 3.

TABLE 3 | LETTER SYMBOLS OF THE LEGEND

LANDFORM

MORAINAL

GREEN

- **ME** *End moraine*
- **MG** *Ground moraine*
- **MH** *Hummocky moraine*

GLACIOFLUVIAL

YELLOW

- **GD** *Ice contact delta, esker delta, kame delta, delta moraine*
- **GE** *Esker, esker complex, crevasse filling*
- **GK** *Kame, kame field, kame terrace, kame moraine*
- **GO** *Outwash plain, valley train*

GLACIOLACUSTRINE

BLUE

- **LB** *Raised (abandoned) beach form*
- **LD** *Glaciolacustrine delta*
- **LP** *Glaciolacustrine plain*

GLACIOMARINE

- **WD** *Glaciomarine delta*
- **WP** *Glaciomarine plain*

ALLUVIAL

- **AP** *Alluvial plain*

COLLUVIAL

- **CS** *Slope failure*
- **CT** *Talus pile*
- **CW** *Slopewash and debris creep sheet; minor talus*

EOLIAN

- **ED** *Sand dunes*

ORGANIC

GREY

- **OT** *Organic terrain*

BEDROCK

- **RL** *Bedrock plateau*
- **RN** *Bedrock knob*
- **RP** *Bedrock plain*
- **RR** *Bedrock ridge*
- **/R** *Bedrock below a drift veneer*

MATERIAL

- **b** *boulders, bouldery*
- **c** *clay, clayey*
- **g** *gravel, gravelly*
- **p** *peat, muck*
- **r** *rubble*
- **s** *sand, sandy*
- **m** *silt, silty*
- **t** *till*

TOPOGRAPHY

LOCAL RELIEF

- **H** *Mainly high local relief*
- **M** *Mainly moderate local relief*
- **L** *Mainly low local relief*

VARIETY

- **c** *channelled*
- **d** *dissected, gullied*
- **j** *jagged, rugged, cliffed*
- **j*** *cliffed volcanic rock signature*
- **k** *kettled, pitted*
- **n** *knobby, hummocky*
- **p** *plain*
- **r** *ridged*
- **s** *sloping*
- **t** *terraced*
- **u** *undulating to rolling*
- **w** *washed, reworked*

DRAINAGE

SURFACE CONDITION

- **W** *Wet*
- **D** *Dry*
- **M** *Mixed wet and dry*
- **h** *Suspected high water table*

LETTER SYMBOLS USED TO DESCRIBE COMPONENTS

MATERIAL TYPE AND LAYERING

Soil material constituents of a landform are shown by lower case letters which precede the upper case letters used to denote the landform type and variety. For example, sGE denotes sand(s) in a glaciofluvial (G) esker (E). Since all bedrock landforms consist of rock, they do not require a material designation.

Two or more materials in the same landform are shown in order of dominance. Thus, sgGO indicates that sand(s) is dominant and gravel (g) is subordinate, resulting in a gravelly sand glaciofluvial outwash (GO) deposit.

Near-surface layering of contrasting materials is indicated by a slash (/). Where a slash is shown, the upper material has a different origin and composition from the underlying material. For example tMG/R indicates glacial till in a ground moraine deposit overlying bedrock; pOT/cLP indicates a blanket of peat in organic terrain overlying the clay of a glaciolacustrine plain. The occurrence of contrasting materials in the subsurface is inferred from features that are recognizable in stereoscopic pairs of airphotos. No precise thickness is suggested for the surficial layer.

LANDFORM BASIC TYPE AND VARIETY

The first upper case letter in the landform component of the *letter code* designates the landform basic type according to its origin. Commonly encountered examples are M for moraine, G for glaciofluvial, L for glaciolacustrine, O for organic, and R for bedrock. Six basic types of landform are composed of mineral soil materials, one is composed of organic material, and one of bedrock.

The second upper case letter indicates variety. For example, there are three varieties of moraine (end, ground, and hummocky moraine) and five varieties of bedrock (plateau, knob, plain, ridge, and bedrock below a drift veneer).

The letters for basic type and variety are combined into the landform component as in the following examples: MG for ground(G) moraine(M), GO for glaciofluvial(G) outwash plain(O), LD for glaciolacustrine(L) delta(D), and RR for bedrock(R) ridge(R).

TOPOGRAPHY

Local relief is indicated by upper case letters. Relief is based on a stereoscopic interpretation of the airphotos and is therefore only approximate. The 1:50 000 scale National Topographic System maps should be consulted for more precise determinations of the relief in any map-area of interest. For the purposes of this study, the relief has been divided into three categories: low relief (L), where the difference in local elevations is generally less than 15 m; moderate relief (M), where the difference is between 15 m and 60 m; and high relief (H), where the difference is usually greater than 60 m.

Topographic variety within each of these three categories represents local shapes, forms, or processes; they are associated mainly with recognizable erosional and depositional processes and may be glacial or postglacial in age and origin. Topographic variety is indicated by lower case suffixes, such as c for channelled, k for kettled, d for dissected, t for terraced, and n for knobby or hummocky.

An example of the complete topographic component is Lu, depicting a low relief terrain (L) that is undulating to rolling (u) in appearance. An area exhibiting complex topography may contain two or more lower case letters to indicate the different varieties.

DRAINAGE

The surface drainage condition of the landscape is classified in three groups as interpreted from the aerial photographs: dry, wet, or mixed wet and dry. These three conditions are indicated by the capital letters D, W, and M, respectively. A qualifying suffix, h, indicates a possible high water table, a condition inferred from stereoscopic airphoto interpretation. The suffix h is most commonly used to describe the near-surface drainage condition of granular deposits where the ground surface is dry, yet a high water table is postulated. This condition is shown as Dh.

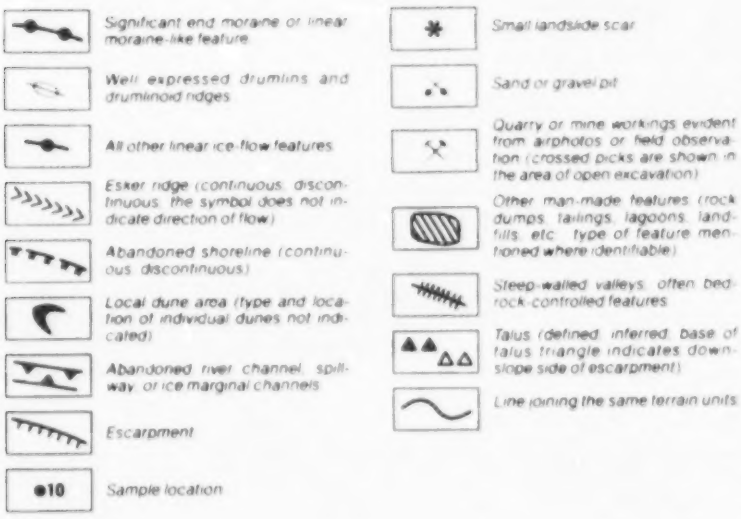
GRAPHIC SYMBOLS

In addition to the letter symbols previously described, a number of graphic symbols are used on the Data Base Maps. These graphic symbols are shown in Table 4.

EXAMPLES OF THE LETTER CODING SYSTEM

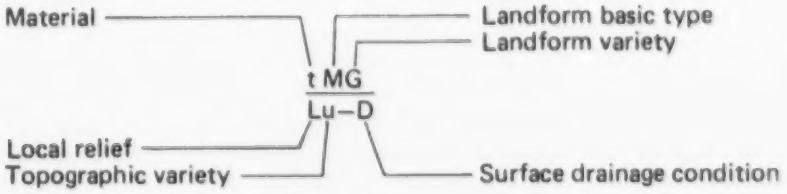
Each engineering terrain unit shown on the Data Base Maps is described by a letter code. These codes can be simple, complex, or a combination of both. This section gives sample interpretations of a typical simple terrain unit and two complex terrain units. The next section deals with some of the techniques used in recording complex terrain units.

TABLE 4 | GRAPHIC SYMBOLS ON THE DATA BASE MAPS


Significant end moraine or linear moraine-like feature
Well expressed drumlins and drumlinoid ridges
All other linear ice-flow features
Esker ridge (continuous, discontinuous; the symbol does not indicate direction of flow)
Abandoned shoreline (continuous, discontinuous)
Local dune area (type and location of individual dunes not indicated)
Abandoned river channel, spillway, or ice marginal channels
Escarpment
•10
Sample location
Small landslide scar
Sand or gravel pit
Quarry or mine workings evident from airphotos or field observation (crossed picks are shown in the area of open excavation)
Other man-made features (rock dumps, tailings, lagoons, landfills, etc.; type of feature mentioned where identifiable)
Steep-walled valleys, often bedrock-controlled features
Talus (defined, inferred; base of talus triangle indicates downslope side of escarpment)
Line joining the same terrain units

SIMPLE TERRAIN UNIT

Simple terrain units occur where only one landform is found in the area outlined.

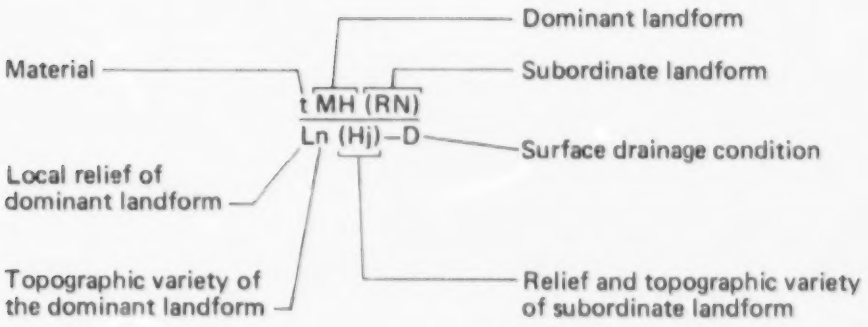


The terrain unit described by this letter code is a ground moraine (MG) composed of glacial till (t). Topography is low (L) and undulating (u) and the surface drainage condition is dry (D).

COMPLEX TERRAIN UNIT

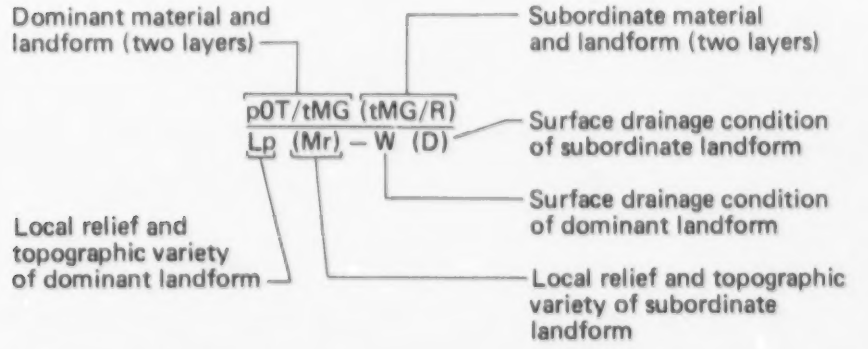
In highly complex terrain units the dominant landform is shown first and the subordinate landform follows in parentheses.

Example 1



This terrain unit consists of glacial till material in a hummocky moraine (MH). The subordinate landform within the complex consists of bedrock knobs (RN). The topography of the dominant landform is one of low relief (L) and is knobby or hummocky (n). The subordinate landform has high relief (H) and is jagged or rugged (j). The ground surface is generally dry (D) in both the dominant and subordinate landforms. Note that the topography in parentheses refers to the landform shown in parentheses.

Example 2


Dominant material and landform (two layers)
Subordinate material and landform (two layers)
pOT/tMG (tMG/R)
Lp (Mr) – W (D)
Surface drainage condition of subordinate landform
Surface drainage condition of dominant landform
Local relief and topographic variety of dominant landform
Local relief and topographic variety of subordinate landform

The dominant landform in this terrain unit consists of peat or muck (p) in organic terrain (OT) overlying till (t) in ground moraine (MG). The subordinate landform in this complex terrain unit consists of till (t) in ground moraine (MG) overlying bedrock (R). Topography of the dominant landform is one of low relief (L) with a plain-like aspect (p). The subordinate landform has moderate relief (M) and is ridged (r). The ground surface is wet (W) in the dominant landform and dry (D) in the subordinate landform. Note that the topography and drainage shown in parentheses in this example refer to the landform shown in parentheses.

Figure 2 illustrates typical materials and physical settings for some common terrain units.

EXPLANATION OF TECHNIQUES USED FOR COMPLEX LETTER CODES

Some parts of the terrain are more complex than others and require special designations. These include the slash, comma, or dash in certain parts of the letter code. Also, to enhance the readability of the maps, colour was used. The rationale behind these techniques is described below.

THE SLASH

Near-surface layering of contrasting materials is indicated by a slash. Where a slash is used, the upper material has a different origin and composition than the underlying material. For example, tMG/R indicates a stony sandy till in ground moraine overlying bedrock. The occurrence of contrasting materials in the subsurface is inferred from features that are recognizable in stereoscopic viewing of airphotos. No precise depth is suggested for the surficial layer, however, in many planning and construction situations the presence of a certain underlying material can be significant.

THE COMMA, DASH, AND SEQUENCE OF PARENTHESES

A comma has been used by some of the interpreters to divide complex dominant landforms such as sGO,sGK. It takes on the meaning "and" in this context. Thus sGO,SGK indicates the presence of sandy outwash and sandy kame landforms. Other interpreters use a dash to signify the same conditions (e.g. sGO-sGK). It is important to remember that the comma and the dash as explained here are quite different from the slash which indicates a layered sequence.

Where there is more than one subordinate landform, a sequence of parentheses has been used by some interpreters while others used a comma. Thus, (sGO,RN) and (sGO)(RN) both signify that the subordinate landforms are sandy outwash and bedrock knobs.

THE USE OF COLOUR

On the Data Base Maps, standardized colours are used to highlight morainal (green), glaciofluvial (yellow), glaciolacustrine (blue), and organic (grey) landforms; but no colours are used for bedrock, alluvial, colluvial, or eolian landforms, or where no one landform was judged to be dominant.

In the case of layered or complex units, colour enhances the landform which is most important from an engineering standpoint.

The following examples help to illustrate this use of colour:

sGE	Coloured yellow.
sGE(sLP/sGE)	Coloured yellow, since sGE is dominant.
sLP/sGE	If coloured blue, the lacustrine sands are judged to have the most significance in engineering works. If coloured yellow, then the interpreter judged sGE to be most significant from an engineering viewpoint.
sGO-tMG(pOT/sGO)	This complex terrain unit has no single dominant landform so it is normally left uncoloured. If the interpreter judged the outwash to be more significant for most engineering works, the unit would be coloured yellow.

The colours are meant only to facilitate the reading of the Data Base Maps. The user must consider all symbols in the letter code to obtain the full description of a particular terrain unit.

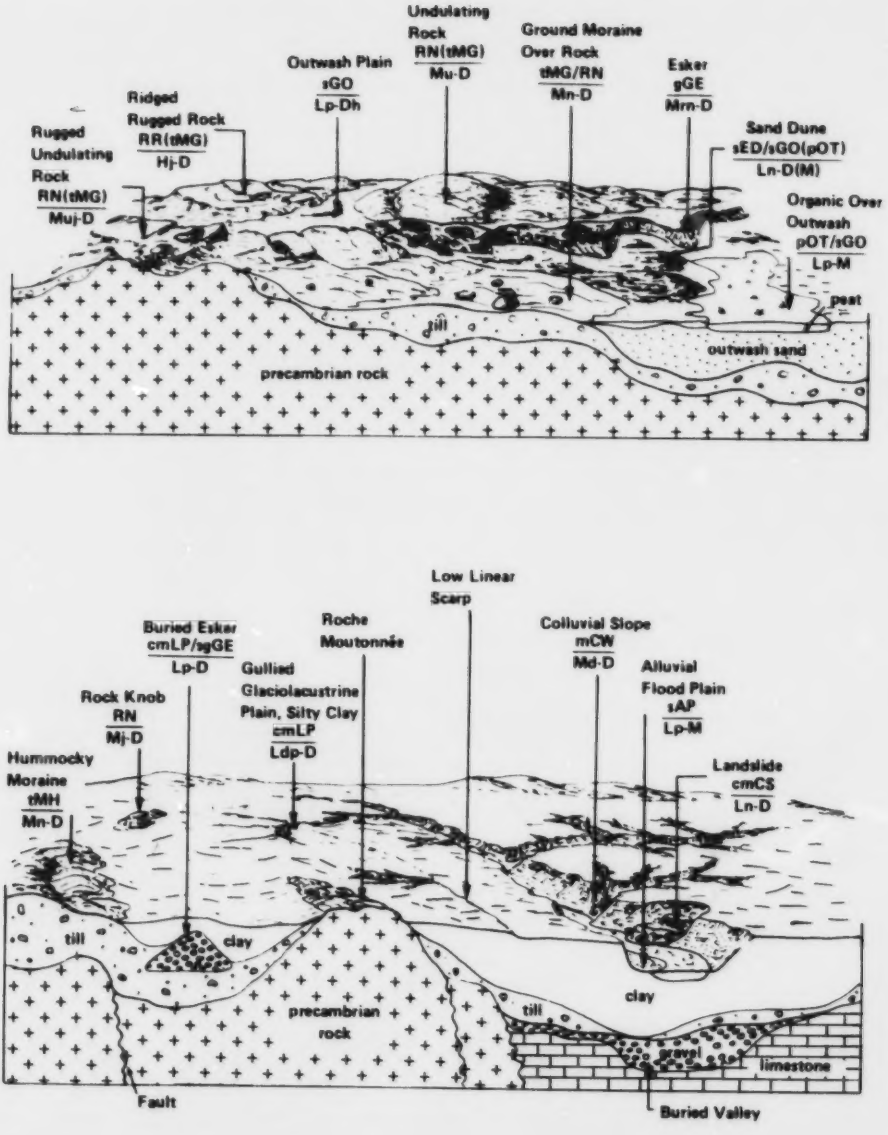
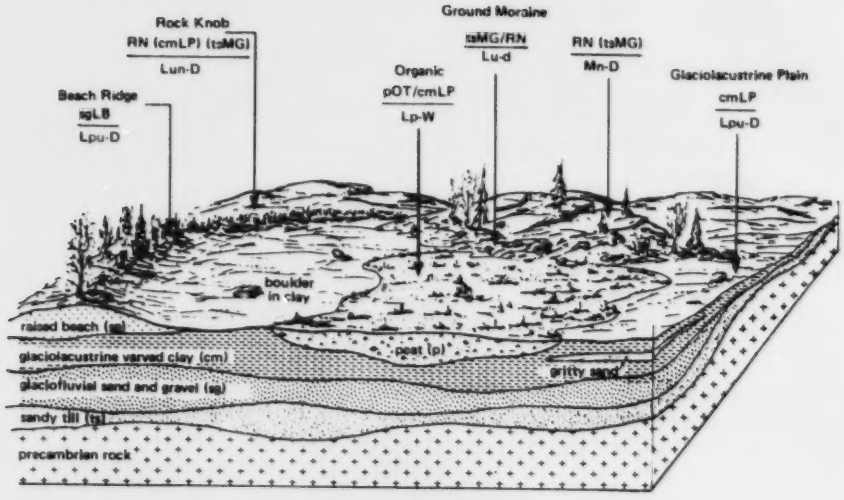
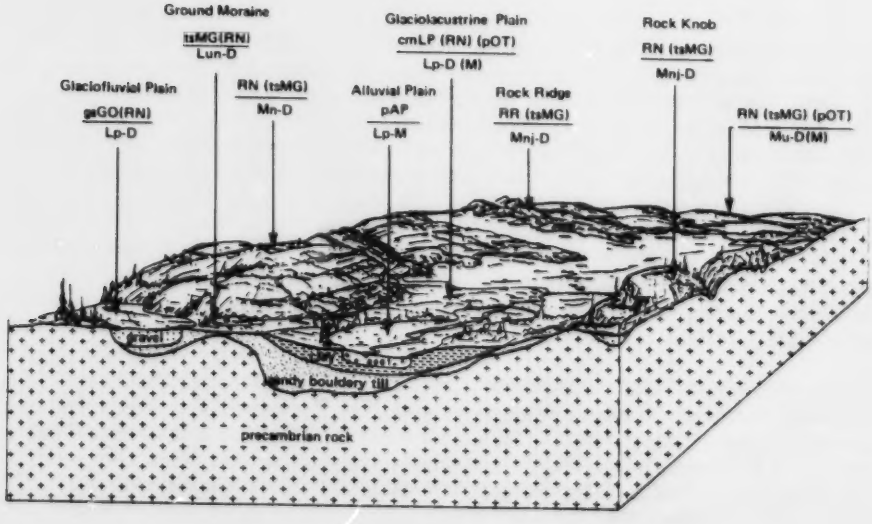
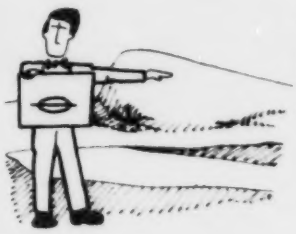


Figure 2 –Diagrammatic sketches showing typical terrain types and their representative letter codes.


Rock Knob
RN (cmLP) (tsMG)
Lun-D
Beach Ridge
sgLB
Lpu-D
Organic
pOT/cmLP
Lp-W
Ground Moraine
tsMG/RN
Lu-d
RN (tsMG)
Mn-D
Glaciolacustrine Plain
cmLP
Lpu-D
boulder in clay
raised beach (sg)
glaciolacustrine varved clay (cm)
glaciofluvial sand and gravel (sg)
sandy till (ts)
precambrian rock
peat (p)
gritty sand


Ground Moraine
tsMG(RN)
Lun-D
Glaciofluvial Plain
gGO(RN)
Lp-D
RN (tsMG)
Mn-D
Alluvial Plain
pAP
Lp-M
Glaciolacustrine Plain
cmLP (RN) (pOT)
Lp-D (M)
Rock Ridge
RR (tsMG)
Mnj-D
Rock Knob
RN (tsMG)
Mnj-D
RN (tsMG) (pOT)
Mu-D(M)
gravel
sandy bouldery till
precambrian rock



CHAPTER FOUR
Engineering Characteristics Of Terrain Units

Each of the four components of the letter code that designates a terrain unit has certain engineering characteristics that are broadly predictable. The variation of these characteristics for each component is briefly discussed below and specific examples and explanations are given. A combined consideration of the four components thus leads to some understanding of the engineering characteristics of an entire terrain unit.

ENGINEERING CHARACTERISTICS OF LANDFORMS

The terrain classification system is based on the identification of landforms and the characteristic soil or rock materials of which they are composed. In general, landforms are units of landscape that 1) exhibit characteristic topographic and drainage forms, 2) are composed of soil and rock materials with characteristic engineering properties and construction qualities, and 3) have recurring geological associations. The type of landform reflects the origin and composition of the soil and rock materials and the history of weathering and erosion processes that have affected them.

Nine major landform units have been identified within the legend format and these have been subdivided into twenty-two separate landform varieties. Knowing the origin of the landform, one has some indication of its geotechnical characteristics.

BEDROCK LANDFORMS

Five types of bedrock landforms have been included in the legend:

RL	Bedrock plateau,
RN	Bedrock knob,
RP	Bedrock plain,
RR	Bedrock ridge, and
/R	Bedrock below a drift veneer.

No attempt has been made to distinguish the lithology or composition of the bedrock landform types. If such information is required, users should refer to the published bedrock geological reports and maps listed in the reference list for each map-area.

Much of northern Ontario consists of rugged to undulating bedrock terrain. A thin mantle of drift covers the rock, but in most places it is less than one metre thick. However, the drift can be locally much thicker, especially on the flanks of outcrops or between bedrock hills. This type of terrain has been mapped as follows:

RN(tMG/R) or tMG/R(RN) or MG/R

Bedrock terrain has a number of engineering constraints. Although bearing capacities are usually excellent, blasting is required for excavations, earth borrow is scarce, ground water resources are unpredictable, and trafficability is poor.

MORAINAL LANDFORMS

Three types of morainal landforms are are shown in the legend:

ME	End moraine,
MG	Ground moraine, and
MH	Hummocky moraine.

The material found in these landforms is almost entirely glacial till. Most till is composed of a wide range of grain sizes, from clay to boulders, with the finer sizes comprising the till matrix.

In engineering literature, tills are usually described as well graded materials having low permeability, high strength, low moisture content, and high bulk density. Although most tills encountered during this study possess these characteristics, local tills in certain areas vary widely in grain-size distribution and other geotechnical characteristics. Such variations depend largely on the kind of soil and rock materials over which the glacier passed, and on the local environment and mode of till deposition. The clay fraction in some ground moraine tills is so dominant that they have the appearance and geotechnical properties of glaciolacustrine clay. In such cases, the landform is shown on the Data Base Map as tcMG. Such tills occur southwest of Thunder Bay and in the Cochrane-Hearst area of northeastern Ontario.

Near Geraldton, the tills have a high percentage of silt-sized material and resemble the carbonate-rich tills found in some areas of southern Ontario. They are described as tmMG on the maps. Most tills in the study area, however, have a silty sand matrix with an abundance of pebbles, stones, and boulders. They are represented on the maps as t, ts, or tb.

The following is an example of a typical terrain unit in which a morainal landform is dominant:

$$\frac{\text{tMG(RN)}}{\text{Lu-D}}$$

tMG These symbols indicate the origin and material of the landform: till in ground moraine. From an engineering viewpoint, one can expect good bearing capability, good borrow potential, adequate shear strength for most applications, and generally good overall engineering characteristics.

(RN) These letter symbols indicate that bedrock knobs are a subordinate landform within the terrain unit. Thus, in some areas, blasting may be necessary for excavations.

Lu-D These symbols indicate that the landform is an undulating plain of low relief (Lu) with dry (D) surface drainage conditions.

In both end moraines (ME) and hummocky moraines (MH), some till was deposited during ablation of glacial ice. This has resulted in water sorting of some of the materials and the possibility of a significant variation in soil types. For example, the tills can be extraordinarily bouldery, or there can be buried deposits of water-sorted sands and gravels. Engineering characteristics can also vary. It is important that the user be aware of these possible variations.

GLACIOFLUVIAL LANDFORMS

Landforms deposited by glacial meltwater have been divided into two groups:

a) ice-contact

- GD Ice-contact delta; esker delta; kame delta; delta moraine.
- GE Esker; esker complex; crevasse filling.
- GK Kame; kame field; kame terrace; kame moraine.

b) proglacial

- GO Outwash plain; valley train.

Materials contained in these landforms have been transported and deposited by glacial meltwaters and generally consist of gravel, sand, and silt. Where outwash has been deposited during stagnant ice conditions, the materials can be quite variable and the topography very irregular. Outwash deposited over proglacial plains and in valleys tends to be less variable and often horizontally stratified.

Glaciofluvial landforms of all kinds are good aggregate prospects. Where the landforms are small, they may provide materials for local use; if large, they may contain resources of regional significance.

These landforms also are good areas in which to search for potential ground water supplies. The possible presence of permeable sands and gravels, especially where the deposits are deep, means that outwash landforms and buried esker complexes can contain important aquifers.

Because the glaciofluvial landforms have good foundation conditions and suitable borrow and granular materials, they represent good possibilities for transportation routes, building sites, forest management areas, and airport locations.

A typical example of a glaciofluvial terrain unit is:

$$\frac{\text{sgGO}}{\text{Lp-D}}$$

sgGO These symbols indicate the origin and materials of the landform. Sand (s) is dominant, but a significant amount of gravel (g) is present. Because of the glaciofluvial outwash origin (GO), it is a potential source of aggregate, probably has good bearing capacity for structures, and the material can be excavated without difficulty and compacted easily into fills. If the deposit is thick it could contain a good ground water source.

Lp-D These modifiers show the landform to be a low relief plain (Lp) with a dry surface (D), characteristics which further enhance its importance from an engineering viewpoint.

GLACIOLACUSTRINE LANDFORMS

Three different types of glaciolacustrine landforms are identified in the legend:

LB Raised (abandoned) beach ridge (or beach form),
LD Glaciolacustrine delta, and
LP Glaciolacustrine plain.

The engineering characteristics of the beach ridges (LB) and the deltas (LD) are generally superior to those of the lake plains (LP). Beach ridges and deltas may contain sand and possibly gravel. These materials have generally good geotechnical properties and are often suitable as mineral aggregate.

The lake plain deposits are more likely to contain fine-grained sediments consisting of silts and clays. Often these will be layered into varves (i.e. alternating thin bands of silt and clay). Geotechnical properties of these sediments are usually poor. Shear strengths are low and can decrease with depth, bearing capacities are poor, and susceptibility to frost can be high. The soils can have high moisture contents and be difficult to handle and compact.

The following is an example of a typical terrain unit in which a glacio lacustrine landform is dominant:

$$\frac{\text{cmLP(pOT)}}{\text{Lp-M(W)}}$$

cmLP This indicates that the dominant landform is a massive silty clay or varved clay and silt (cm) lake plain (LP). Engineering characteristics are poor because of the fine-grained nature of the soils and the mode of deposition of these sediments.

(pOT) The poor engineering conditions are further complicated by the existence of peaty organic terrain (pOT) as a subordinate landform. Soft and compressible soils can be expected.

Lp-M(W) This indicates that the unit is a low-relief plain (Lp). The dominant landform has mixed wet and dry (M) surface drainage, while the subordinate landform is wet (W). Poor engineering characteristics may be inferred from these poor drainage conditions.

GLACIOMARINE LANDFORMS

Landforms formed where glacial meltwaters carry sediment into glaciomarine waters are divided into two types:

WD Glaciomarine delta, and
WP Glaciomarine plain.

For many engineering and land-use development purposes the geotechnical characteristics of glaciomarine deltas (WD) are superior to those of glaciomarine plains (WP), primarily because the deltas may contain sand and possibly gravel. These materials possess good properties for many types of engineering construction, including mineral aggregate.

The glaciomarine plain deposits consist mainly of silts and clays, that are commonly massive and seldom layered. The geotechnical properties of glaciomarine plain sediments are generally poor. Bearing capacities are low; shear strengths are also generally low and can decrease with depth. Moisture contents tend to be high. Glaciomarine deposits are often "sensitive", i.e. the initial shear strength can be destroyed through vibration or remoulding of the soil material. As a result, landslides may occur suddenly along steep slopes. These deposits can be difficult to handle and compact during construction. Those having a high silt content are susceptible to frost heave.

The following is an example of a terrain unit in which the landform is a glaciomarine plain:

$$\frac{\text{mcWP}}{\text{Lpt-Dh}}$$

mcWP The landform is a glaciomarine plain (WP). The material in this landform is clayey silt (mc).

Lpt-Dh The topography is a low-relief plain (Lp) which has been terraced (t), likely by moving water. The ground is dry but the water table is near the surface (Dh).

ALLUVIAL LANDFORMS

Most stream channels and their associated flood plains, which are called alluvial plains (AP), vary in width and in the evenness of their longitudinal profiles. They are often too small to be mapped or even subdivided into form and material varieties, such as braided or meandering, at a mapping scale of 1:100 000. Only a few streams (e.g. the Vermilion River north of Sudbury)

show classic sinuous meandering and oxbow patterns on wide valley floors. Such meandering is commonly confined to low gradient, fine to medium sand, deltaic plains.

Very few streams in Ontario show a typical braided pattern. Rather, a high proportion of streams show narrow channels paved with boulders and containing isolated areas of gravel, sand, and organic silt.

Floodplains characterized by a fine upper stratum of overbank silt and fine sand, overlying coarser deposits are common in some regions. Their surfaces may be swampy and they often contain local peat deposits. Rapids and falls occur where streams cross and erode into rock ledges and bouldery till. Small and large lakes are commonly strung out along the larger rivers. These lakes trap much of the sediment being carried by the stream.

Alluvial plain deposits generally have poor engineering characteristics. Sediments are often loose and organic materials are common. The plain is prone to flooding and water tables are near the surface. The erosion of the banks, scour of beds, and deposition of sediments all pose potential hazards for many engineering works.

The following description of a typical alluvial terrain unit letter code illustrates some of the engineering characteristics of the unit:

$$\frac{\text{smAP}}{\text{Lp-W}}$$

smAP The letter symbols AP indicate that the landform originated by deposition of materials during a flood stage of a stream. The deposit may be layered and only normally consolidated (i.e. the soils are compacted only by their own weight and have not been preconsolidated by higher pressures in the past). The material is silty sand (sm) and the unit probably has the following general engineering properties: moderate to low shear strength, especially when wet; moderate permeability; high frost susceptibility; and high erosion potential.

Lp-W The topography is planar with low relief (Lp) and the surface is wet (W). This wet condition will decrease the shear strength and could cause "quick" conditions in excavations.

COLLUVIAL LANDFORMS

These landforms, which consist of material that has reached its present position through the force of gravity, are of three different types:

CS Slope failure,
CT Talus pile, and
CW Slopewash; debris creep; soil creep; minor talus.

Individual failures and talus piles are usually too small to map at a scale of 1:100 000.

Slope failures, which generally occur in glaciolacustrine (LP) and glaciomarine (WP) sediments, are a good indicator of unstable soil conditions and poor engineering characteristics. Talus piles have a natural angle of repose of about 35° and may be unstable if they are disturbed. Slopewash sheets are commonly veneers that are usually too thin to be easily recognized on the airphotos. When shown on maps, they have generally been inferred. They have poor engineering properties.

EOLIAN LANDFORMS

Sand dunes (ED) are the only eolian landform shown on the Data Base Maps. They consist of material that has been transported and deposited by the wind. Thin deposits of eolian sand also occur but have not been differentiated on the maps.

Because dune deposits have a uniform grain size (almost entirely between 0.05 and 0.5 mm) they are typically unstable in steep cuts. The uniformly graded sands are too fine for most aggregate uses. Stabilization of cuts in dunes is often required, because if ground water tables are near the surface, dune materials can become "quick" under vibratory loads. Gullying is also a common engineering hazard in eolian landforms.

ORGANIC TERRAIN

No attempt has been made to distinguish among marsh, swamp, bog, or fen. All peatlands have simply been mapped as organic terrain (OT). The organic material is peat and muck and the landform is often confined; stagnant drainage and wet surface conditions are common.

Organic terrain has exceptionally poor engineering characteristics. The shear strength is very low, compressibility is high, and ground water tables are at or near the surface. Many organic areas are prone to flooding, with resulting constraints for many types of development. Depths of surface peat and underlying soft sediments are not known and should be investigated on-site, by hand augering or drilling.

ENGINEERING CHARACTERISTICS OF MATERIALS

At a reconnaissance scale of mapping, one can only infer general engineering characteristics of soil and rock materials. Estimation of the geotechnical properties and their significance for a particular use must take into account the origin of the material and its relation to the landform in which it is found.

A few examples illustrate the significance of this statement:

sGO In this sandy outwash, one would expect to find material grading from silty fine sand to sand, which may contain a few lenses of fine gravel. Because the material was deposited by glacial meltwaters, a broad range of grain sizes is expected to occur within the sand and possibly fine gravel categories.

sED In contrast to the previous example, these letter symbols indicate sand in a dune form. Wind has been the agent responsible for the erosion, transportation, and deposition of the sediment. Thus, the material will have a uniform grain size and a narrow grading envelope (i.e. a fine to medium sand with no coarse sand or fine gravel).

sLP This sand occurs in a glaciolacustrine plain and was deposited on the bottom of a lake, probably not far from shore. In general, the material texture will range from fine to medium sand. Coarse sand and fine gravel lenses will be rare, but they may occur locally.

The modes and environments of sediment depositon and the subsequent geological processes modifying these sediments have a strong influence on a number of geotechnical parameters. Geological processes can determine whether:

- a cohensionless granular soil deposit is likely to be loose or dense,
- the soil will have a high or low permeability,
- a clay-rich cohesive soil material is likely to possess high, intermediate, or low shear strength,
- clays will have high, medium, or low compressibility under loads, and
- materials are likely to possess frost-heave characteristics that can adversely affect pavements and rigid structures.

The determination of engineering characteristics of materials from terrain evaluation information, therefore, requires knowledge and understanding of the geotechnical properties and a grasp of the significance of the several geological processes that formed the materials.

The following is a list of the materials which appear in the terrain unit letter codes, together with a brief statement on the engineering significance of each:

b –boulders, bouldery.
These are mapped in association with a variety of landform types, but wherever they are encountered they will create problems for engineering works.

c –clay, clayey.
In general, clays are associated with a number of potential geotechnical problems, such as low shear strength, high compressibility, poor material handling, and poor surface drainage.

g –gravel, gravelly.
Where these materials are present in the terrain unit, the user may expect permeable soils, a potential source of aggregate, and generally good engineering characteristics.

p –peat, muck.
Peat and muck appear most consistently as the material in organic terrain. The map user should expect poor engineering conditions.

r –rubble.
These are generally angular rock fragments that are commonly associated with talus piles. They can cause difficulties for engineering works due to their occasional large size and their association with unstable talus slopes.

s –sand, sandy.
Engineering characteristics can be quite variable, depending upon the origin of these materials and the geological agents that eroded, transported, and deposited them.

m –silt, silty.
These fine-grained soils can have poor geotechnical properties. Their existence in a terrain unit should alert the map user to potential engineering problems.

t –till.
Glacial till materials vary in their geotechnical properties, so that detailed studies are nearly always warranted. Till, however, is considered to have generally good engineering characteristics.

ENGINEERING SIGNIFICANCE OF TOPOGRAPHY

The topography of a landform within an engineering terrain unit is described in terms of its relief and variety of form. Since the topography has generally been interpreted only from an analysis of the airphotos, the user should refer to the 1:50 000 scale National Topographic System maps, which are available for all of the map-areas. The letter symbols for relief (H, M, L) are therefore meant to provide only a first level of reference in assessing the potential engineering conditions of the terrain. Even so, there are some general guidelines that are applicable at this reconnaissance scale:

H This designates high relief, with local elevation differences exceeding 60 m. The cost of engineering works will likely be higher in this type of terrain than in flatter areas due to a greater number of cut-and-fill operations and the necessity for extensive grading operations where level ground surfaces are required. If the landform is bedrock, blasting can be anticipated. Route alignments will be difficult to select and construction costs are generally high.

M Moderate local relief is often in the range of 15 to 60 m. It should be emphasized that these figures are estimates only and that topographic maps should be consulted where more accurate data are required. Engineering conditions within areas of moderate relief can be variable, depending upon many other factors. The significance of the symbol must be assessed in conjunction with the other components of the letter code.

TABLE 5 | ENGINEERING CHARACTERISTICS FOR VARIETIES OF TOPOGRAPHY

	VARIETY		ENGINEERING CHARACTERISTICS
c	channelled	–	problems associated with drainage crossings; drainage
d	dissected, gullied	–	slope problems; erosion
j	jagged, rugged, cliffed	–	complex slopes; alignment problems; grading problems
k	kettled, pitted	–	stagnant drainage; coarse glaciofluvial soils
n	knobby, hummocky	–	complex slopes; slope problems; erosion; alignment problems
p	plain	–	poor drainage; good alignments
r	ridged	–	alignment problems; grading problems
s	sloping	–	erosion
t	terraced	–	coarse soils in glaciofluvial landforms
u	undulating to rolling	–	good alignments; good trafficability
w	washed, reworked	–	complex soils

L Low local relief, generally less than 15 m, has certain advantages for some engineering purposes such as alignment selection but disadvantages for others. The surface of low relief terrain is often poorly drained, thereby creating potential drainage problems for many engineering works. When flat areas are underlain by alluvial plains (AP), organic terrain (OT), lake plains (LP), or marine plains (WP), terrain conditions for many engineering uses are often far from ideal.

The topographic variety designations provide some indication of the nature or type of terrain. They may give significant clues to the geotechnical properties of the terrain units. Table 5 lists the topographic variety modifiers and associated engineering characteristics.

ENGINEERING SIGNIFICANCE OF DRAINAGE

Evaluation of surface drainage of a terrain unit is important when the significance of a terrain unit is inferred for engineering works. The letter symbol for drainage allows the user to form an understanding of such conditions.

Four categories of drainage are included in the legend:

W wet surface conditions,
D dry surface conditions,
M mixed wet and dry surface conditions, and
h suspected high water table.

WET SURFACE DRAINAGE (W)

When this symbol appears in the terrain unit letter code, a wet surface condition is indicated. Such a situation is commonly associated with organic terrain (OT), alluvial plains (AP), glaciolacustrine plains (LP), and glaciomarine plains (WP).

Wet conditions usually result in increased engineering costs. This is due to the poor geotechnical properties that are often associated with a high soil-water content, and the need for flood control, improvement of surface drainage, and dewatering. This is especially true for silt, clay, and peat.

The presence of the symbol W in any terrain unit letter code should therefore alert the user to the possibility of poor engineering conditions.

DRY SURFACE DRAINAGE (D)

This symbol indicates dry surface conditions, as interpreted from the aerial photographs. Existence of this symbol in the terrain unit letter code suggests good engineering characteristics related to surface drainage.

MIXED WET AND DRY (M)

Often an area of ground will have both wet and dry surface features. This is especially true where complex terrain units are mapped. A typical example would be:

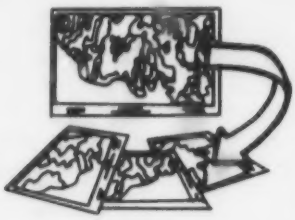
$$\frac{\text{RN(pOT,tMG)}}{\text{Mn-D(M)}}$$

Mixed drainage conditions indicate the existence of potentially wet ground conditions, and the associated engineering problems.

SUSPECTED HIGH WATER TABLE (h)

This symbol indicates a possible high water table, as inferred from the stereoscopic airphoto interpretation. For example, Dh signifies dry surface drainage and a suspected high water table.

Knowledge of suspected high water tables can have a significant effect on the planning of engineering and resource development projects. The drainage component of the letter code allows the user to assess the existence of adverse ground water conditions and problems associated with poor surface drainage. Two examples serve to illustrate the inferences that can be drawn from the drainage component: trafficability over a glaciolacustrine clay plain (cLP) that is wet (W) can be very difficult; and extraction of gravel from a gravelly outwash deposit (gGO) that has a high water table (Dh) could require dewatering operations.



CHAPTER FIVE
Derivation Of User Information

PRINCIPLES AND GUIDELINES FOR DERIVING USER INFORMATION

The user of engineering geology terrain maps must make qualitative judgements about the physical characteristics of different soil and rock materials, and the terrain in which they occur. The objective may be to obtain geological engineering, construction, or resource information; regardless of the objective, each study usually necessitates some sort of terrain appraisal.

In order to become as familiar as possible with the terrain, the user should investigate all available relevant information in addition to that contained on the Data Base Maps. This activity may involve the study of existing topographic maps, stereoscopic examination of airphotos; review of geological and pedological reports and maps, engineering soil studies, and land-use data; and even a visit to the area of interest.

When using the engineering terrain information contained in the report folios, the user must keep in mind that the data are reconnaissance in nature. The reports give an inventory of regional engineering terrain conditions and their purpose is to provide a guide for engineering and resource planning functions that is compatible in accuracy with a scale of 1:100 000. Information provided in the reports and maps is not sufficiently detailed to be used for design purposes.

The Data Base Maps provide a reconnaissance classification of the terrain based on identification of the origin, materials, topography, and drainage of geologic landforms. From this classification, it is possible to infer general geotechnical characteristics for each terrain unit, and then to rate the units in terms of these characteristics. Unless ground-truth information is available in the form of laboratory test results or measured stratigraphic sections, tentative geotechnical ratings assigned to each unit should be considered as educated guesses only. Even so, this knowledge of the terrain can be invaluable when formulating planning strategies or designing follow-up field studies.

The following three levels of user information can be derived from the Data Base Maps:

1. engineering characteristics,
2. suitability or capability maps, and
3. multiple information maps.

The engineering characteristics are derived from an interpretation of the terrain unit letter codes and provide a framework of geotechnical information inferred from these codes. Suitability or capability maps are derived for particular uses. The user of such maps should have an appreciation both of the engineering characteristics and of their significance. Multiple information maps combine engineering characteristics with a number of different suitability maps to produce the highest level of derivation.

The next three sections deal with the different levels of information that can be derived and show that the extent and usefulness of this information is related to the effort and expertise of the user.

FIRST LEVEL OF DERIVATION: ENGINEERING CHARACTERISTICS

Some of the more common geotechnical characteristics that can be inferred from the terrain unit letter codes are:

1. shear strength,
2. compressibility,
3. plasticity,
4. permeability,
5. bulk density,
6. natural water content of soil,
7. susceptibility to frost action,
8. texture of soil,
9. conditions of slopes (refer to topographic maps),
10. proximity of bedrock,
11. complexity of stratigraphy,
12. position of ground water table, and
13. surface drainage conditions.

For a first level of derived information, the user should study the letter codes shown on the Data Base Maps and relate them to any or all of these geotechnical characteristics. For instance, a first estimate of the shear strength of a terrain unit can be made and rated as high, moderate, or low. Similarly the permeability can be judged as high, moderate, or low; slopes can be described as steep, moderate, or flat; and water-table positions can be estimated as high, low, or in many cases, unknown.

Derivation of this information by the map user requires a knowledge of the significance of the legend symbols, as they relate to the engineering characteristics. For example, the shear strength of material in a landform is related to the stress history of that particular soil. If the material was deposited under glacial ice, it will have a different stress history than if it had been deposited by sedimentation into a lake, or by wind action. Also, shear strength is closely related to the water content of the soil, its plasticity, and the position of the water table. Standard textbooks on soil mechanics and manuals of engineering geology and airphoto interpretation, provide references for this type of information (*see* References).

SECOND LEVEL OF DERIVATION: CAPABILITY MAPS

The engineering significance of a terrain unit can be related to specific uses by means of a second level of derivation. This involves an assessment of the geotechnical characteristics for a particular purpose or use, and assumes an appreciation of the disciplines of geology, soil mechanics, and engineering.

For example, it is possible to derive a map which shows the suitability of the terrain, in terms of bearing capacity, for engineering structure foundations. The person doing the derivation must understand the relationships between soil moisture, shear strength, compressibility, and the location of the water table. Similarly, the terrain units can be rated in terms of their suitability for earth borrow. In this case, the user must analyze and rate the importance of material texture, plasticity, bulk density, frost susceptibility, and soil-water content.

The following are some examples of the derived information that can be obtained from an analysis of the Data Base Maps and the previously described geotechnical characteristics of the terrain units:

1. bearing capacity,
2. earth-borrow suitability,
3. stability of slopes,
4. necessity to dewater excavations,
5. ease of shallow excavations,
6. contaminant migration hazard,
7. suitability for septic systems,
8. general construction capability,
9. relative rating of site-grading conditions,
10. aquifer potential,
11. generalized susceptibility to flooding,
12. sand and gravel potential,
13. overburden drilling conditions,
14. subgrade suitability for roads, and
15. severity of cut-and-fill conditions.

The purpose of this level of derivation is to provide simplified information on one or a number of criteria, so that the user can make informed judgements on the suitability of the various terrain units with respect to the stated criteria.

THIRD LEVEL OF DERIVATION: MULTIPLE INFORMATION MAPS

In many planning and feasibility studies, the user requires the compilation of a large amount of data on one map. For example, in site selection studies, the planner should have engineering terrain information on at least the following conditions in order to make informed decisions:

1. foundation suitability,
2. site-grading requirements,
3. ground-water supply potential,
4. ease of installing below ground services,
5. source of mineral aggregates,

6. suitability for septic systems,
7. stability of slopes,
8. surface drainage conditions, and
9. suitability for road subgrades.

More items could be added to this list depending upon the use for which the site was being selected, but it serves to illustrate the many types of information required for such a map.

Further examples of multiple information maps include:

1. waste disposal,
2. route selection,
3. aggregate resources,
4. airport location selection, and
5. terrain management.

Each of these maps requires the interpretation and evaluation of a number of factors, and their usefulness is related to the effort and expertise of the person who carries out the derivation.

EXAMPLES OF DERIVED INFORMATION

A number of derived maps have been produced by the authors to illustrate the types of information that can be obtained from the Data Base Maps. A list of these maps is given in Tables 1 and 2.

The purpose of this section is to describe briefly some of the general techniques used in producing the various derived maps.

SAND AND GRAVEL RESOURCES

The first task in deriving a Sand and Gravel Resources Map is to identify, from the letter symbols on the Data Base Map, all landforms which may contain economic deposits of sand and gravel. In decreasing order of importance, these landforms and their representative letter symbols are:

GO	Outwash,
GE	Esker,
GD	Glaciofluvial delta,
GK	Kame,
LB	Raised beach,
MH	Hummocky moraine,
ME	End moraine,
LD	Glaciolacustrine delta, and
WD	Glaciomarine delta.

The next letter symbol in the code indicates the material. The most promising terrain units for coarse aggregate are those in which the material is gravel (g), sandy gravel (gs), or gravelly sand (sg). Less promising are those shown as sand (s) or even silty sand (sm).

The topography letter symbols L (Low), M (Moderate), and H (High) have little significance in the evaluation of aggregate resources, except to indicate the ease of development of a potential deposit.

Finally, the drainage letter symbol h indicates a possible high water table, a situation which could make an otherwise favourable aggregate deposit uneconomic. The presence of the letters W, M, or Dh in the letter code means that a dewatering problem may be associated with the extraction of any aggregate.

SEPTIC SYSTEMS CAPABILITY

Soil texture, slope, proximity of bedrock to the surface, and depth of the water table are the main criteria to be examined when judging the suitability of a terrain unit for tile bed facilities. A topographic map should be used in conjunction with the Data Base Map. Terrain units whose letter codes indicate high (H) to moderate (M) relief and rugged (j) or knobby (n) topography will have inherent siting problems due to steep and complex slopes. Bedrock terrain (RN, RP, RR, RL) or units where moraine forms only a thin veneer over bedrock (tMG/R) may have insufficient soil cover for construction of tile fields. Organic terrain (pOT) is also unsuitable for the siting of tile fields. Terrain units with symbols indicating wet conditions (W) or high ground-water tables (Dh) also present problems. Clay (c) and clayey silt (mc) soils are often unsuitable for the proper operation of septic tile fields unless special engineering designs are implemented to raise the tiles above these impermeable soils.

CONSTRUCTION CAPABILITY

Evaluation of construction capability is related primarily to the relative ease or difficulty of moving rock or earth. Thus, problems could be encountered during construction in terrain units which exhibit one or more of the following conditions:

1. presence of bedrock landforms (RN, RP, RR, RL),
2. high (H) to moderate (M) relief,
3. jagged (j), channelled (c), dissected (d), knobby (n), or ridged (r) topography,
4. presence of numerous boulders (b), and
5. wet drainage conditions.

FOUNDATION CAPABILITY

Bedrock terrain units (RN, RP, RR, RL) generally have the best foundation conditions, but fault zones and major fractures should be avoided. The user should refer to published bedrock geology reports for data on these features of the bedrock. Outwash deposits (GO) and ground moraine (MG) also have good foundation conditions. Glaciolacustrine clay plains (cLP), glaciomarine clay

plains (cWP), and organic terrain (pOT) often have poor foundation conditions, due to the presence of soft and compressible soils. Other landforms with the potential for inherent foundation problems include slope failures (CS), talus piles (CT), and alluvial plains (AP). Foundation problems can occur in any terrain units whose letter codes indicate rugged relief (j), bouldery soil (b), or a suspected high water table (W).

EXCAVATION CAPABILITY

Excavations for sewers, water mains, or any underground facilities are generally expensive and difficult where the dominant landform is bedrock (RN, RP, RR, RL). Organic terrain (OT) and alluvial plains (AP), both of which can exhibit wet drainage (W) or a high water table (Dh), may require dewatering and trench support. Where the material is bouldery (b), peaty (p), or contains rubble (r), excavations can be difficult. Problems associated with trench stability and bottom heave might be encountered within glaciolacustrine clay plains (cLP) and glaciomarine clay plains (cWP).

LANDFILL CAPABILITY

The engineering terrain maps, by themselves, do not provide sufficient information for the location of solid-waste disposal facilities. However, they are valuable sources of information when analyzed in conjunction with water-well data, topographic maps, and stratigraphic sequences. Glaciofluvial landforms (e.g. GO, GD), organic deposits (OT), alluvial plains (AP) or bedrock terrain (e.g. RN, RP) all require careful scrutiny prior to selection as landfill sites. They are often poor environments for disposal unless ground-water flow directions and gradients and pertinent attenuation data have been analyzed, and found to be suitable. Bedrock terrain may lack sources of proper cover material and commonly does not allow sufficient attenuation or dilution of the leachate. Within glaciolacustrine plains (cLP) and glaciomarine plains (cWP), the main landfill siting problems relate to surface-water pollution and cover-material suitability. Other terrain units with wet drainage conditions (W) or a suspected high water table (h) are often unsuitable for the same reasons.

GROUND-WATER DEVELOPMENT CAPABILITY

Engineering terrain maps can be of considerable assistance in outlining potential ground-water supplies, but they must be supplemented with additional data. Outwash deposits (GO), especially if they are deep, provide good aquifer potential. Glaciolacustrine clay plains (cLP) and glaciomarine clay plains (cWP) are generally not good target areas unless they are underlain by more permeable strata at depth. Water supplies in bedrock terrain are limited to the open fractures, joints, and faults.

ROUTE SELECTION

All transportation routes, whether they are for highways, access roads, railways, pipelines, or hydro lines, have certain common requirements. These requirements vary considerably in importance but form common factors in locating optimum routes. Probably the most important factor is horizontal alignment and grade. It is therefore important to study the topography component of the terrain unit letter code. For example, a route alignment through high and rugged relief (Hj) will generally be considerably more expensive than one across a flat plain (Lp). However, if the landform along the flat plain happens to be thick peat in organic terrain (pOT), serious problems would still be encountered. This shows that the landform and material designations must also be taken into account.

MINERAL EXPLORATION CONDITIONS

Although the Data Base Maps are not intended to show areas of favourable mineralization, they should aid the prospector or exploration geologist in planning drift sampling programs and interpreting geophysical results. The maps can be used effectively as an aid for locating access roads to drilling sites and sites for base camps. Areas of suspected conductive overburden (e.g. cLP, pOT) can be identified, and certain overburden-drilling problems assessed before the drilling program commences.

APPENDIX

Glossary Of Selected Terms

ALLUVIUM—Sediment composed of organic material, clay, silt, sand, gravel, cobbles, or boulders deposited by postglacial streams.

AQUIFER—A body of sediment that contains sufficient saturated permeable material to conduct ground water and yield economically significant quantities of ground water to wells and springs.

ARTESIAN AQUIFERAquifer where the water is confined and thus under pressure, with the piezometric surface rising above the top of the aquifer.

BEACH RIDGE—An essentially continuous low ridge of beach material (sand, gravel, shingle) deposited by waves and currents. May occur singly or as a series of approximately parallel deposits which represent successive lake levels.

BEDROCK—A general term for regions of solid rock which may be exposed or covered by unconsolidated material of any origin.

BOULDER—A rock fragment with an average dimension of 0.3 m or more.

CANADIAN SHIELD—A large area in Canada composed almost entirely of igneous and metamorphic rocks of Precambrian age.

CLAY—Soil particles having a diameter of less than 0.002 mm .

COLLUVIUM—Sediment deposited by any process of mass wasting or by overland flow. Includes various types of slides, flows, and falls, as well as creep phenomena and slopewash deposits.

COMPRESSIBILITY—Property of a soil pertaining to its susceptibility to decrease in volume when subjected to loading.

CONSOLIDATION—In geology, any or all processes (cementation, compaction, crystallization) whereby loose earth materials are changed into hard rock. In soil mechanics, consolidation is the process whereby soil particles are packed more closely together in response to increased pressure being applied to the soil mass. Usually water is expelled from the voids as the soil particles are forced closer together. Consolidation is most marked in thick, normally loaded, highly plastic clay and other cohesive soils of low permeability.

CONTINENTAL GLACIATION—Glaciation of continental scale.

CREVASSE FILLING—A long and narrow, relatively straight ridge composed of stratified sand and gravel deposited in a crevasse of a wasting glacier and left standing after the ice has melted.

DELTA—A low, relatively flat tract of land deposited at the mouth of a river as the river flows into a large, standing body of water. A delta is commonly fan shaped and often composed of granular materials.
DIABASE—A special type of gabbro, occurring in dikes and sills, that is common in the Cobalt area.
DIKE—A tabular mass of intrusive igneous rock that cuts obliquely or transversely across older rocks.
DISCHARGE—The quantity of water that passes a given point in a given unit of time.
DIVIDE—The high points of land that separate adjacent drainage basins.
DRAINAGE—The process of removal of surplus surface water or ground water by natural or artificial means. It includes surface and subsurface drainage.
DRUMLIN—A streamlined hill of glacial till with its long axis parallel to the direction of flow of the glacier which formed it.
DUNE—A mound or ridge of predominantly fine sand deposited by the wind.
ENGINEERING GEOLOGY—The application of geological information and principles to engineering projects, particularly mining and civil engineering.
EOLIAN—Eroded, transported, or deposited by wind action.
ERRATIC(glacial)—A transported fragment of rock that differs from the bedrock beneath it. The agent of transport was glacier ice or floating ice.
ESKER—A long, narrow, sinuous ridge of stratified drift deposited by melt water on, in, or under a glacier.
FAULT—A fracture along which the opposite sides have been displaced relative to each other.
FINE-GRAINED SOIL—Soil consisting mostly of clay and silt. In the Unified Soil Classification System, in geotechnical engineering, more than 50 percent by weight must be smaller than 0.074 mm in diameter. This includes soil that is subject to significant strength and volume changes, and is relatively impervious and difficult to drain.
FLOOD—1) A relatively high flow event in a stream. 2) A defined high flow condition (e.g. mean annual flood, design flood). 3) An overbank flow condition.
FLOOD PLAIN—The part of any stream valley that is inundated during floods.
FLUTINGS—Smooth, straight, parallel grooves formed by erosion at the base of a glacier. Flutings are parallel to the direction of ice movement.
FOUNDATION—The soil or rock upon which a building or other engineering structure rests and transmits its load. Also, the lower part of such a structure that transmits the load to the soil or rock below it.
GLACIAL DEPOSIT—A mass of earth materials deposited directly by a glacier or which may have been reworked by its meltwaters.
GLACIAL LAKE—A lake fed predominantly by glacial meltwater or a lake in a depression in part closed by glacial ice. Includes lakes not directly adjacent to the glacier and lakes lying against or on a glacier, and fed mainly by waters derived from the melting of a glacier.
GLACIATED—1) Has been worn down by glacial action or covered with glacial drift. 2) Covered by, or modified by the action of, a glacier.
GLACIOFLUVIAL—Pertaining to streams flowing from glaciers or to the deposits made by the streams.

GLACIOLACUSTRINE—Pertaining to or characterized by glacial and lacustrine (lake) conditions. Material deposited in lakes affected by glacier ice, or deposited by meltwater flowing directly from glaciers into a lake.
GLACIOMARINE—Pertaining to or characterized by glacial and marine conditions. Material deposited in a marine environment affected by glacier ice, or deposited by meltwater flowing directly from glaciers into a marine environment.
GRAVEL—An unconsolidated, natural accumulation of rock fragments resulting from erosion. Consists mainly of particles larger than sand (diameter greater than 4.76 mm).
GROUND MORAINE—A flat to undulating accumulation of till, with closed depressions and without pronounced transverse elements. It may show streamlined flow features oriented in the direction of glacier advance.
GROUND WATER—Subsurface water occurring below the water table (phreatic surface) in the saturated zone in which all pores are filled with water under hydrostatic pressure. This contrasts with subsurface water above the water table, which is referred to as soil moisture.
GROUND-WATER DISCHARGE—Release of water from the zone of saturation to the surface.
HUMMOCKY MORAINE—Moraine characterized by knob-and-kettle topography. The hummocky relief may have been produced in the marginal zone of a glacier by dumping from live ice or sliding and sloughing off of stagnant ice, with the burial of ice blocks that later melt to produce kettles. The mounds usually occur in large numbers with individual mounds either similar or dissimilar in size and shape.
ICE-CONTACT DEPOSITS—Primarily glaciofluvial materials deposited on or banked against a supporting stagnant ice mass.
IGNEOUS ROCK— Rock formed from the cooling and solidification of magma.
IMPERVIOUS—Term applied to soil or rock materials (e.g. clay or shale) through which water cannot pass or passes with great difficulty and at very slow rates.
INTERBEDDED—1) Occurring between beds. 2) Beds of one kind of soil or rock deposited between beds of a different composition.
JOINT—A fracture in a rock along which no displacement has occurred. A joint differs from a fault in lacking displacement on opposite sides of the fracture.
KAME—A short irregular ridge, hill, or mound of stratified drift deposited by meltwater and in contact with glacier ice.
KETTLE or KETTLE HOLE—A sharply outlined, closed depression in glacial drift created by the melting of a mass of underlying ice. Many kettles are steep-sided, bowl-shaped depressions resembling a kettle drum in form.
LANDFORM—A topographic feature of the earth's surface formed by natural causes and processes. It may be erosional or depositional, and may have had a simple or complex geologic history.
LANDSLIDE—A general term for an entire group of phenomena that involves the downslope movement of natural masses of soil and rock materials, artificial fills, or mixtures of these. It does not include creep phenomena or snow avalanches.

LINEAMENT—Significant lines or linear elements in landscape that reveal something about the geological characteristics of the underlying soil or rock materials.
MEANDER—A looplike bend of a stream channel.
MELTWATER—Water resulting from the melting of snow and glacier ice.
MORAINE, MORAINAL—Accumulation of glacial material (mainly till) deposited by glaciers.
MUCK—Highly decomposed organic material in which the original plant parts are not recognizable. Contains more mineral matter and is darker in colour than peat, and usually accumulates under wet conditions of poor or imperfect drainage.
ORGANIC TERRAIN—Ground consisting of a surficial layer of living vegetation and a sublayer of peat or fossilized plant detritus of any thickness.
OUTWASH PLAIN—A body of water-sorted material that forms a broad plain beyond the margin or former margin of a shrinking glacier, and commoly consisting of a number of coalescing outwash fans. Varieties are called outwash terraces, fans, aprons, or valley trains.
OVERBURDEN—1) The barren soil, rock, or waste overlying coal, placer deposits, or an orebody at open pit mines. 2) Material of any nature, consolidated rock or unconsolidated soil deposits, that overlies economic materials, such as sand and gravel, coal, and ore, that are mined from the surface. 3) Any loose soil material that overlies bedrock. 4) Equivalent to the term "regolith" in some cases.
OVERCONSOLIDATED SOIL DEPOSIT—A soil deposit that has been subjected to an effective pressure greater than the present overburden pressure.
PEAT—A component of organic terrain consisting of fragmented remains of plant matter (e.g. mosses, sedges, grasses, trees) sequentially deposited and partly decayed. Also, unconsolidated compressible material consisting largely of decomposed or slightly decomposed organic matter accumulated under conditions of excessive moisture.
PERMEABILITY—The capacity of a porous medium to transmit a liquid or gas subjected to an energy gradient (in the case of water, hydraulic gradient).
PIPING—The movement of soil particles in the subsurface by percolating waters, leading to the development of subsurface caves and channels.
PLASTICITY—The property of a soil that allows it to be deformed beyond the point of recovery without cracking or appreciable change in volume.
PLEISTOCENE—The earlier of the two epochs into which the Quaternary Period of geological time is generally divided. Colloquially called the Glacial Epoch or the Ice Age.
POSTGLACIAL—Pertaining to the time period since the disappearance of the continental glaciers from a particular area.
PRECAMBRIAN—Refers to all geologic time and its corresponding rocks prior to 600 million years ago.
PRECAMBRIAN SHIELD—A vast region of the earth's crust that is old and worn down, and is composed mostly of Precambrian igneous and metamorphic rocks. Five Precambrian Shields occur in the world, one of which is the Canadian Shield.

PRECONSOLIDATION—The greatest effective pressure to which a soil has been subjected. Also called preloading or precompression, as a preconsolidated, preloaded, or precompressed soil.
PROSPECTING—The search for indications of workable mineral deposits, usually located on or near ground surface. When the indicator minerals are found in glacial deposits, the term "drift prospecting" is employed.
QUATERNARY PERIOD —The youngest period of the two geologic time divisions of the Cenozoic Era. The Quaternary is subdivided into the Pleistocene and Recent (or Holocene) Epochs. It comprises all geologic time and deposits from the end of the Tertiary (approximately 2 million years ago) until and including the present.
RAISED BEACH—A sand and gravel ridge elevated above the present level of a lake or sea in which it was formed. It indicates a change in the relative level of land and water surfaces. Raised beaches also mark the former shorelines of extinct lakes, many of them of Pleistocene age. Also referred to as an abandoned beach.
RECHARGE—Natural or artificial replenishment of ground water by injection or by infiltration of water from the surface.
RECONNAISSANCE—General examination or survey of the main features of an area or site, usually carried out before a more detailed survey.
RELIEF—The difference in altitude between the high and low parts of a land surface. Synonymous with topography.
ROCHE MOUTONNÉE—A glacially molded rock outcrop having a smooth, gently sloping, rounded, upstream side — the result of abrasion; and a steep, rough, irregular, downstream side — the result of plucking.
ROCK—Geologically, any naturally formed, consolidated aggregate of mineral matter constituting an appreciable part of the earth's crust.
ROCKFALL (and DEBRIS FALL)—The rapid descent of a mass of rock (debris), vertically from a cliff or by bouncing down a slope; a mass of fallen rock.
SAND—In engineering, rock fragments smaller than gravel and larger than coarse silt (i.e. having a diameter ranging from 0.074 to 4.76 mm).
SANITARY LANDFILL or SANITARY FILL—A deposit resulting from the disposal of solid wastes (garbage) by spreading it in layers and covering it with impervious soil materials to control rats, insects, odours, and wind-blown litter.
SEDIMENT—Earth material that has been transported. Includes both mineral and organic material deposited by water, air, ice, or gravity.
SEPTIC TILE FIELD—That portion of a private sewage system in which aerobic bacterial decay occurs.
SHALE—A laminated sedimentary rock composed of compacted or cemented mud.
SILT—In geotechnical engineering, material passing the No. 200 U.S. standard sieve, that is nonplastic or only very slightly plastic, that exhibits little or no strength when air dried, and that tends to become "quick" and unstable when saturated.
SLOPE STABILITY—Resistance of a natural or artificial slope to failure by landsliding, including translational and rotational slides, flows, falls, and spreads.

SOIL CREEP—The imperceptibly slow downslope movement of surficial soil and rock materials.
STRATIFIED—Arranged in, or composed of strata or layers.
STRIATIONS (glacial)—Linear scratches on bedrock surfaces caused by grinding of rock against rock during movement of glacier ice.
TALUS—Coarse, angular fragments of rock and subordinate soild material dislodged by weathering (temperature and moisture changes) moved downslope primarily by the pull of gravity, and collected at the foot of cliffs and other steep slopes.
TERRAIN ANALYSIS—The process of identifying and interpreting the significance of terrain and its features. It includes the influence of weather and climate on terrain and involves identification of the geologic processes that may affect the environment.
TILL—An unsorted mixture of clay, silt, sand, pebbles, cobbles, and boulders deposited directly by glacier ice.
TOPOGRAPHY—Natural or physical surface features of a region, commonly shown on a map by contour lines.
TRAFFICABILITY—The relative ease with which various land vehicles can move across the terrain, taking into account such factors as drainage conditions, slope, and soil material.
UNDULATING—Having a moderately rolling surface or form.
UPLAND—A highland. Ground elevated above lowlands and valleys.
VALLEY—Any hollow or low-lying tract bounded by terraces, hills, or mountains and commonly traversed by a stream that drains the surrounding upland.
VARVE—A distinctive couplet of layers representing an annual deposit in sedimentary materials regardless of origin and usually consisting of two contrasting laminae or layers: one a thick light-coloured layer of silt and fine sand deposited in the spring and summer, and the other a thin dark-coloured layer of clay deposited in the fall or winter.
WATER TABLE or PHREATIC SURFACE—A surface in the saturated zone below ground level along which the hydrostatic pressure is in equilibrium with the atmospheric pressure.
WELL GRADED SOIL—Soil material having a continuous distribution of grain sizes from coarsest to finest constituents in such proportions that successively smaller grains fill the pore spaces between the larger grains.
WIND EROSION—The detachment, transportation, and deposition of soil materials by the action of wind. The removal may be in more or less uniform sheets or as localized blowout hollows.

SELECTED REFERENCES BY SUBJECT

AIRPHOTO INTERPRETATION

Avery, T.E.
1977: Interpretation of Aerial Photographs, Third Edition; Burgess Publishing Company, Minneapolis, 392p.

Blair, C.L., and Simpson, R.I.
1967: The Canadian Landscape: Map and Airphoto Interpretation; The Copp-Clark Publishing Company, Toronto, 172p.

Lillesand, T.M., and Keiter, R.W.
1979: Remote Sensing and Image Interpretation; John Wiley and Sons, Toronto, 612p.

Lueder, D.R.
1959: Aerial Photographic Interpretation: Principles and Applications; McGraw-Hill Book Company, Incorporated, Toronto, 462p.

Mathur, B.S., and Gartner, J.F.
1968: Principles of Photo Interpretation in Highway Engineering Practice; Materials and Testing Division, Ontario Department of Highways, 236p.

Mollard, J.D.
1978: Landforms and Surface Materials in Canada: A Stereoscopic Airphoto Atlas and Glossary, Sixth Edition; J.D. Mollard and Associates, 815 McCallum-Hill Building, Regina, Saskatchewan, 5p., plus 67 / stereophotos and 50p. glossary.

Reeves, R.G. (editor)
1975: Manual of Remote Sensing, Volume II: Interpretation and Applications; American Society of Photogrammetry, Falls Church, Virginia, 2144p.

Way, Douglas S.
1973: Terrain Analysis — a Guide to Site Selection Using Aerial Photographic Interpretation; Dowden, Hutchison, and Ross Incorporated, Stroudsberg, Pennsylvania, 392p.

SOIL MECHANICS

Canadian Geotechnical Society
1978: Canadian Foundation Engineering Manual, Parts 1 to 4; Canadian Geotechnical Society, Montreal, 352p.

Craig, R.F.
1975: Soil Mechanics; Van Nostrand Reinhold Company, New York, 275p.

Lambe, T.W., and Whitman, R.V.
1979: Soil Mechanics, SI Version; John Wiley and Sons, Toronto, 553p.

Peck, R.B., Hanson, W.E., and Thornburn, T.H.
1972: Foundation Engineering, Second Edition; John Wiley and Sons, New York, 514p.

Terzhagi, Karl, and Peck, R.B.
1967: Soil Mechanics in Engineering Practice, Second Edition; John Wiley and Sons, New York, 729p.

ENGINEERING GEOLOGY

Krynine, D.P., and Judd, W.R.
1957: Principles of Engineering Geology and Geotechnics; McGraw-Hill Book Company, Toronto, 730p.

Legget, R.F.
1962: Geology and Engineering, Second Edition; McGraw-Hill Book Company, Toronto, 884p.
1973: Cities and Geology; McGraw-Hill Book Company, Toronto, 624p.

McFarlane, I.C. (editor)
1969: Muskeg Engineering Handbook; Muskeg Subcommittee of the National Research Council Associate Committee on Geotechnical Research, University of Toronto Press, Toronto, 297p.

National Research Council, Canada
1973: Proceedings: National Conference on Urban Engineering Terrain Problems; National Research Council Technical Memorandum Number 109, 333p.

Radforth, N.W., and Brawner, C.O. (editors)
1977: Muskeg and the Northern Environment in Canada; University of Toronto Press, Toronto, 399p.

INTERESTING AND RELATED ARTICLES CAN BE FOUND IN RECENT ISSUES OF THE FOLLOWING JOURNALS:

- Bulletin of the Association of Engineering Geologists
- Bulletin of the International Association of Engineering Geology
- Canadian Geotechnical Journal
- Quarterly Journal of Engineering Geology

AND IN THE FOLLOWING PUBLICATIONS:

- Engineering Geology Case Histories of the Geological Society of America
- Memoirs and Papers of the Geological Survey of Canada
- Proceedings, First (1970), Second (1974), and Third (1978) International Congresses of the International Association of Engineering Geology
- Professional Papers and Circulars of the United States Geological Survey

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